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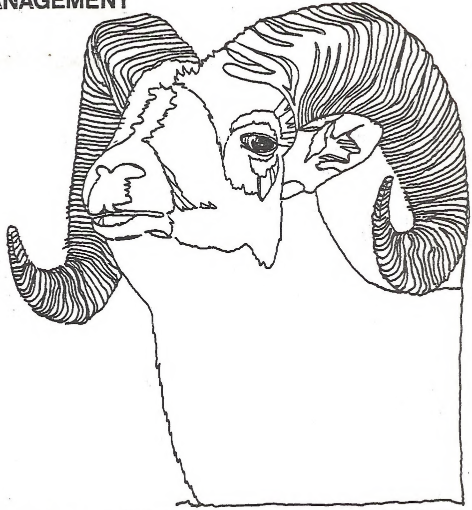

ECOLOGY OF THE DESERT BIGHORN SHEEP IN SOUTHEASTERN UTAH

FIRST OF FOUR YEARLY REPORTS

By
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FIRST YEAR FINAL REPORT

THE ECOLOGY OF THE DESERT BIGHORN SHEEP IN SOUTHEASTERN UTAH

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ABSTRACT

A review of literature regarding ecology of desert bighorn sheep was conducted. Summaries of material concerning bighorn life history, movements, foraging habits, relationships with livestock, recreation, mining, and other human influences are presented. Also historical material regarding the desert bighorn sheep in Utah has been summarized.

Fieldwork began in February 1981 when seven desert bighorn sheep were captured and fitted with radio transmitters. Data and results of research to date are presented regarding bighorn sheep movements, foraging habits, habitat utilization, influence of mining, recreation, livestock, and diseases.

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Utah Division of Wildlife Resources personnel captured and collared the bighorn sheep for the study. Special thanks goes to them for their willingness to participate in the sometimes dangerous operation. Jim Bates, has provided invaluable assistance in providing information and equipment to the project. The truck for the project and living quarters at Fry Canyon, Utah were also provided by the UDWR. Their assistance and cooperation is most appreciated.

Thanks also goes to Canyonlands National Park officials for the information regarding recreation use in the study area.

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INTRODUCTION

Purpose

The desert bighorn sheep (*Ovis canadensis nelsoni*), native animals to the harsh canyon country of southeastern Utah, is one of the most sought after game animals in North America for consumptive as well as nonconsumptive purposes. As a component of arid and often times fragile desert ecosystems, it requires close management as our human population expands it's realm of use into bighorn sheep habitat for mineral exploration and extraction, livestock operations, recreation opportunities, etc. Expanded human use into bighorn habitat necessitates good research to determine ecological requirements of the bighorn so that critical components may be protected and conserved to insure that the desert bighorn sheep will always be a part of our desert ecosystems.

Desert bighorn sheep have been studied extensively by several researchers in Utah during the past 15 years. Wilson (1968) conducted the first study on desert bighorn sheep in Utah. His pioneering study was conducted primarily in the rugged canyons of San Juan county, Utah, particularly in the areas of Red and White Canyons. He concluded that the population was static as a result of several limiting factors including: 1) lack of available water, 2) competition with cattle and deer, 3) internal parasites, and 4) high lamb mortality. Wilson also believed that lambing grounds were traditional, with ewes using the same area for lambing year after year. Irvine (1969) in a follow-up

study to Wilson's, concluded that in the Red Canyon area there was no migration of desest bighorn sheep but that seasonal movements due to the availability of water did occur. Contrary to Wilson, Irvine felt that lambing grounds were not traditional and that the population was growing as a result of low lamb mortality. Differences seen by Wilson and Irvine may be attributable to low precipitation during Wilson's study compared to relatively high precipitation during Irvine's study.

Bates et al. (1975) conducted the first telemetry study on Utah's desert sheep in the same general area as the previous studies as well as the Glen-Dark Canyon areas to the north. Radio-collared sheep were monitored via fixed-wing aircraft from 1972-1975 in an effort to learn more of the sheep's seasonal movement and distribution. They found that the rams occupied generally larger home ranges and higher elevations than the ewes.

Dean (1977) conducted the first study on the ecology of desert bighorn sheep in Canyonlands National Park, Utah. He was primarily concerned with the distribution and abundance of sheep within the park. He felt that human and livestock activities in the park were limiting bighorn distribution and recommended that livestock grazing be discontinued within park boundaries. He also found no migration of sheep but did observe seasonal movements by rams before and after the rut as they moved to and from areas of ewe concentration for breeding, similar to the patterns observed by Wilson (1968) and Irvine (1969).

Although these early studies provided much needed baseline data

on sheep distribution and abundance, life history, and behavior. There remain many questions concerning the ecology of the desert bighorn sheep in Utah that remain unanswered. For example, there has never been an intensive follow-up study in the Red-White Canyon area since Irvine completed his work in 1969. Information on current status of sheep movements, abundance and distribution, and population trend is sketchy at best. Since that time, mining and recreation activities have fluctuated, while livestock uses have remained about the same. Mining exploration peaked during the late 1970's and has been declining since then. Recreational activity may have also declined during the same period. An intensive study with the aid of radio telemetry equipment and on-the-ground observations will allow assessment of current population trends and will help in providing data critical fro development of the Bureau of Land Management's land use planning sustem, livestock grazing environmental statement, and for the best possible management of the desert bighorn sheep and it's habitat under the multiple use concept.

Objectives

The first year's study effort with reference to the ecology of the desert bighorn sheep on Bureau of Land Management lands in southeastern Utah includes the following objectives:

1. Literature search
2. Capturing and fitting 10 bighorn sheep with collars equipped with radio transmitters.
3. Begin monitoring movements of bighorn both by aircraft and from the ground.
4. Evaluation of forage utilization by desert bighorn sheep.
5. Evaluation of the influence of recreation, livestock, and mining activities on bighorn sheep.
6. Begin to collect physiological and disease information from all sheep captured during the study.

REVIEW OF LITERATURE

History of Desert Bighorn in Utah

Movements and Distribution

The movement patterns of desert bighorn sheep are related to several factors. Forage conditions, water availability, topographical features, climate conditions, season of year, breeding activities, sex and age of individual animals, and man-constructed barriers are all contributory to observed patterns of sheep movement.

Daily movements, though somewhat consitent, are usually flexible from day to day (Simmons 1980). Wilson (1968) suggested that daily movements of Utah desert sheep were closely associated with distribution of water. Sheep moved to ephemeral seeps and tanks, and usually remained on ranges adjacent to permanent water sources. He reported that average daily movement patterns consisted of sheep arising before dawn and feeding laterally on slopes or downhill toward canyon bottoms. By mid-morning sheep bedded and remained so until mid-day at which time they watered, fed, and bedded by late afternoon. As evening approached, sheep arose and fed uphill toward the base of the Windgate Sandstone Cliffs where they bedded at dark.

Welles and Welles (1961) and Wilson (1968) reported little night movement by desert bighorns. However, Monson (1964), Simmons (1980) and others do indicate some movement on moonlit as well as moonless nights.

McQuivey (1978) suggested that bighorn movements were related to seasonal and climatic conditions. Nevada sheep remained adjacent to permanent water sources during hot summer months, but were able to

range much farther during cooler seasons of the year.

Home range patterns are also related to the above mentioned factors. Availability of water has been ascribed as the primary factor in affecting home range. McQuivey (1978), Leslie and Douglas (1979), Wilson (1968), and Irvine (1969) all suggest that home range size and seasonal movements are directly related to water availability. Wilson (1968) reported that home ranges on the south side of White Canyon in Utah were smaller because of fewer permanent water sources than on the north side of White Canyon.

Bates et al. (1975) reported that movements of radio-collared sheep were greater for rams than ewes between relocations throughout the year. The shortest distances were recorded during the summer and winter. Mean home range for rams was greater than for ewes, similar to reports by Leslie and Douglas (1979).

Home range sizes vary for sex, age, season and area of sheep. Wilson (1968) reported that summer and winter home ranges in southeastern Utah for a known ewe were 4.2 sq. miles and 18.6 sq. miles respectively. He also stated that during the summer, rams on the Windgate Mesa utilized a 3 mile area. Leslie and Douglas (1979) also reported difference in size of home range according to sex, age, and season. They showed the average total home range size for adult ewes to be 14.05 km^2, while the average range for rams of different age classes to be quite different (lambs 8.7 km^2, 1-2yr. 13.0 km^2, 2-3yr. 13.6 km^2, 3-4yr. 17.2 km^2). Summer range for ewes was 6.5 km^2, while summer range for rams wasn't calculated.

Migration patterns are also the product of environmental conditions. Three broad categories of migration patterns have been identified (McQuivey 1978): (1) elevational movements within the same range on a seasonal basis, (2) dispersal away from and return to important water sources depending on time of year, and (3) long-range migrations between mountain ranges on an annual basis which may include elevational movements as well as those to and from water. All categories have been identified in Nevada and other states.

Migration patterns as such have not been identified in Utah desert bighorn sheep. Wilson (1968) did suggest that there was a movement of ewes to traditional lambing grounds each year. Irvine (1969) did not feel lambing grounds were traditional, nor did he note any migration pattern. He felt that the seasonal movements observed were a function of water availability.

Dean (1977) also found no annual migration of sheep in Canyonlands National Park, Utah, but did observe seasonal movements by rams before and after the rut as they moved to and from areas of ewe concentration for breeding. Wilson (1968) and Irvine (1969) noted similar patterns of movement by rams during the breeding season from October through December. McQuivey (1978), Welles and Welles (1961), and Leslie and Douglas (1979) all noted that it wasn't unusual for rams to stray far from their home ranges during the breeding season.

Physiographic features of bighorn habitat may act as natural barriers to bighorn movement. Lakes, rivers, large expanses of dense vegetation such as pinyon-juniper trees, chapparal and salt cedar can all inhibit or limit sheep movements.

Barriers to movement patterns have also arisen because of man's influence. Construction of highways, fences, dams, and reservoirs have served to limit movements by bighorns.

Ferrier (1974) reported that bighorn sheep in Nevada are becoming increasingly reluctant to cross a highway constructed across a traditional migration route in Arizona.

Wilson (1968) suggested that U.S. Highway 95 in southeastern Utah was a barrier to movement of sheep from north of the highway across it to the other side. Crossings were recorded frequently before the highway was paved, but since that time crossings have rarely been observed.

Welles and Welles (1961) reported numerous examples of bighorn feeding beside highways and roads in Death Valley National Monument, California. Graham (1980) concluded that although unfenced highways, did not generally deter bighorn from crossing, as traffic increased and highways widened, there would be an increase in bighorn mortality and a decrease in the number of crossings by sheep at highways.

Russo (in Graham 1980) reported that fences obstruct sheep travel more than any other type of man-made barrier. Sizer (1967) reported that rams have been particularly susceptible to barbed wire; catching their large horns in the wire strands and then struggling, cutting their throat on the barbs, and bleeding to death.

Crossings of the Colorado River were apparently common in early days, but since the advent of dams and reservoirs, such crossings may not be as frequent (Graham 1980).

The past distribution of desert bighorn sheep in Utah was determined by Wilson (1968). Desert bighorn have been confined mostly to canyon portions of the Colorado, Green, and San Juan Rivers, and their tributaries. There also have been sheep sighted in Capitol Reed National Monument and the San Rafael Swell in Emery County (Monson 1980).

A small number of bighorn were planted in Zion National Park in 1973, the stock coming principally from the Lake Mead Area of Nevada (McCutchen 1975).

Rocky Mountain bighorn were released in the Desolation Canyon section of the Green River, above the town of Green River in 1968 and 1971. Bighorn sheep were also transplanted to the Mount Nebo area of central Utah near Payson in 1980.

Forage Utilization

Food habit studies have documented that diets of desert bighorn sheep consist on the average of 20% forbs, 40% grass, and 40% browse (Desert Bighorn Council Technical Staff 1980). However, it should be emphasized that these percentages are averages and may change from season to season, area to area, and population to population.

McQuivey (1978) reported that sheep rumens analyzed since 1956 showed that overall diets of Nevada sheep consisted of 65.3% grasses, 28.2% shrubs, and 6.5% forbs. McQuivey also reported that lamb diets were essentially the same as adult sheep diets from the same areas. Preferred forage plants were squirrel tail (*Sitanion hysterix*), galleta grass (*Hilaria jamesii*), big sagebrush (*Artemisia tridentata*), shadscale (*Atriplex confertifolia*), mormon tea (*Ephedra sp.*), and winterfat (*Eurotias lanata*). Brown and McQuivey (1977) did report that lamb diets in some areas were different than adult diets. Lamb diets in the McCullough and Hiland Ranges in Nevada showed use of 35% grass, 38% forbs, and 17% shrubs, while adults in the same area used considerably more grass and shrubs and less forbs (57% grass, 42% shrubs, 1% forbs).

The findings of Deming (1974) and Todd (1972) indicated that desert bighorn sheep are adapted to utilize a wide variety of food plants. Browning (1980) identified more than 470 different plant species that were known to be utilized by desert sheep. He also suggested that through the northern portion of their range and at higher elevations, grasses comprise the majority of the diet. In southern and more arid areas, browse, forbs, and cacti are more important.

Wilson (1968) reported that the average diet composition of sheep in southeastern Utah from March to November was 35.7% grass, 38.1% browse, and 26.1% forbs (Table 1). Important plant species were galleta grass 27.7%, black brush (Coleogyne ramosissima), 18.3%, Russian thistle (Salsola Kali), 15.3%, single-leaf ash (Fraxinus anomala), 11.9%, bassia (Bassia hyssopifolia), 6.7%, and Indian rice grass (Orzopsis hymenoides), 4.1%. Bates (1980, personal communication) reported similar results for sheep in Canyonlands National Park, Utah. He found sheep diets consisted of 39% grass, 45 % shrubs, and 16% forbs for the summer through the winter 1980. Irvine (1969) reported that diets of hunter-killed rams consisted of 12% grass, 35% browse, and 52% unknowns from stomach samples. Irvine also felt that bighorn sheep were somewhat feeding opportunests and followed availability of new tender growth of browse and succulant new grass.

Information on amount of forage required per sheep per day is scant. However, Thorne (in Desert Bighorn Council Technical Staff 1980) has shown that adult Rocky Mountain bighorn sheep (O.c. canadensis) require 3.93 lbs. (air-dry weight) of forage per day. This figure is generally accepted by biologists as a comparable amount of forage required by desert sheep.

Recommendations by the Desert Bighorn Council Technical Staff for forage - vegetation management (1980) include:

1. Maintenance of a wide variety of grasses, forbs, and shrubs.
2. Maintenance of existing native plant species when bighorn range is in good condition.
3. Initiation of type conversions when vegetation is in poor ecological condition (i.e., vast tracts of juniper, (Juniperous sp), mesquite, (Prosopis sp.)) and fail to provide critical plant species to sheep range.
4. All type conversions should conform to principles of game range management suggested by Plummer et al. (1968).

Influence of Livestock

Conflict or potential conflict between domestic livestock and wild ungulates is a major concern of natural resource managers. While opportunities for conflict exist between all wild ungulates and domestic livestock, as a principle, competition in a natural setting is difficult to demonstrate. Therefore, there is little agreement as to it's general occurrence and importance. Much current thinking is rooted largely in inference and speculation and is controversial at best (Mackie 1978). Several researchers have suggested that competition exists between bighorn sheep and livestock for food, space, and water. However, many of those conclusions have been drawn from studies not designed appropriately to demonstrate competition. Therefore, sweeping statements about the detrimental effects of livestock on bighorn sheep must be closely scrutinized before being accepted as documentation of competition.

Uncontrolled cattle, sheep, and horse grazing during the 1800's has been cited as a major factor in the decline of bighorn sheep populations (Jones 1980). Range destruction and diseases brought by domestic animals are considered to be the major decimating factors (Light et al. 1967).

Gallizioli (1977) has gone so far as to say that if bighorn sheep are to survive, that cattle grazing and other livestock problems must be solved. He further suggested that cattle numbers be sharply reduced in historic bighorn habitats.

Evidence suggesting competition between bighorn sheep and livestock

has been presented by several workers. Halloran (1949) and Halloran Demming (1958) indicated that livestock may compete directly with desert bighorn sheep for forage and water.

Morgan (1971) and Lauer and Peak (1976) indicated that competition existed between cattle and bighorn sheep in Idaho, particularly on winter ranges. Crump (1971) documented an increase in the Wind River bighorn herd in Wyoming after livestock grazing was reduced. Ferrier and Bradley (1970) and Albrechtsen and Reese (1970) concluded that bighorn sheep are intorerant of domestic livestock and in direct competition for food and water on Nevada rangelands. Sands (1964) attributed the bighorn decline in the Big Hatchet Mountains in New Mexico to drought and poor range conditions that were aggrivated by livestock use and over populations of deer.

McQuivey (1978) presented evidence that suggested approximately 90% of bighorn sightings occurred in areas that were not available for livestock use, although areas used by livestock were equally good for bighorn sheep. Barmore (1962), Wilson (1968), and Dean (1977) reported similar patterns of habitat utilization by bighorn and domestic livestock in Utah.

Wilson (1968) suggests that cattle compete with desert sheep for food in areas where desert sheep and cattle ranges overlap and also for water where both species utilize common water sources. Wilson (1969) also suggested that space is a major resource competed for by desert sheep and cattle. He reported a failure for sheep to use areas

occupied by cattle though adequate water and forage were available. Wilson (in Trefethen 1975) reported that in the Red Canyon area of southeastern Utah, sheep were abundant prior to the introduction of cattle. After 25-30 head of cattle were introduced into the area, the sheep no longer used the area. When the cattle were removed, the sheep returned. Wilson (1968) also indicated that sheep had utilized Scorup Canyon in Utah until miners introduced some domestic goats into the area for meat.

Charles Irvine (1969) wrote: "Cattle normally are moved from the Abajo Mountains into white Canyon and the Red House area during the winter. They then used all of the grass and browse which was available to them on the Red Canyon study area. Ninety heifers were brought into Blue Notch Canyon during the spring of 1967. The sheep then moved from the canyon bottoms onto the talus slopes and eventually out of the canyon. They did not return to lamb. Because of this, cattle are believed in some cases to be a limiting factor for sheep. Cattlemen in the area feel that Bighorn sheep will use the same area as cattle. They cite a few instances of lone rams having been seen with the cattle. However, fresh sheep sign was rarely seen in areas inhabited by cattle, even though water and forage were available. Also, canyons normally used by cattle are not presently used by sheep. Furthermore, it is felt that if sheep tolerated cattle, they would not have left Blue Notch Canyon ever after cattle were moved in."

Dean (1977) and Dean and Spillet (1976) felt that bighorn distribution was somewhat limited by cattle in Canyonlands National Park, Utah. Prior to heavy livestock pressure bighorn occupied much of the park. But during their study, bighorn range was restricted to canyons that were isolated from livestock grazing or canyons where the topography prohibited livestock from grazing the entire canyon. Their report has been somewhat substantiated by Bates (1981), (personal communication), who noted a marked expansion in distribution of sheep since the removal of cattle from the park.

The Desert Bighorn Council Technical Staff (1980) expressed concerns about competition between desert bighorn sheep and livestock. They recommended to the degree possible, livestock grazing on public lands should be phased out wherever there is direct or potential competition with bighorn sheep. They also suggested where livestock and bighorn sheep must exist in close proximity the following conditions be met:

1. Adequate forage be alloted for the bighorn population, including a mix of forbs, grass, and browse.
2. All waters should be maintained for bighorn for the seasons that bighorn are present.
3. Special livestock fence construction should meet specifications deemed safe for bighorn sheep.
4. Livestock grazing systems should be avoided which will restrict, alter, limit or deteriously affect the habitat of bighorn.
5. No livestock grazing should be permitted just prior to or immediately following the lambing season.
6. No common water developments for bighorn - livestock use during dry periods if both livestock and bighorn will be present at the same time.

Papez and Tsukamoto (in Jones 1980) reported seeing bighorn waiting off at a distance while cattle drank at springs and tanks in the Highland Range of southern Nevada. This and other observations have caused several workers to urge caution in developing water sources that might attract livestock. On the other hand, Weaver (1968) suggested that limited cattle grazing may be beneficial to bighorn because cattle grazing tended to open up dense vegetation that surrounded many springs that otherwise provided no water.

The livestock grazing history in the bighorn sheep study area in southeastern Utah is limited. The following information was provided by the BLM San Juan Resource Area records (Monticello, Utah).

During the 1940's and 1950's, 4 permittees grazed 7000 cattle and 7180 sheep in the then designated Unit No. 7. The old Unit No. 7 included the area with the current desert bighorn sheep study area plus additional land in what now constitutes the southern portion of Canyonlands National Park along with all land south of Red Canyon to the San Juan River and west to Gran Gulch (Figure 1). The area was approximately 2 to 3 times greater than the current sheep study area. No season of use is listed for sheep, however, prior to 1959, 6640 cattle were grazed from October 16 to May 31 (42,330 AUM's) and from June 1 to October 14, 1000 cattle were grazed (4500 AUM's).

In 1959 the old Unit No. 7 was divided into 3 allotments; the Lake Canyon, White Canyon, and Indian Creek allotments (Figure 2).

From 1959 to 1961, the follwoing numbers of cattle were grazed in the Lake Canyon allotment:

1. 1038 cattle, October 15 to May 30 in the Lake Canyon pasture.
2. 50 cattle, June 1 to October 15 in the Cedar Canyon pasture.
3. 50 cattle, June 1 to October 15 in the Grand Gulch pasture.
4. 100 cattle, June 1 to October 15 in the Red Canyon pasture.

The portion of Red Canyon that was grazed at this time was a side canyon to the Colorado River with riparian habitat. This habitat was lost with the flooding of Lake Powell. The Red Canyon we see today is different than the area that was grazed prior to flooding.

Red Canyon is the only portion of the Lake Canyon allotment that is part of the desert bighorn study area.

From 1961 to 1964, 950 cattle were licensed for winter, plus 200 cattle during the summer in Cedar, Grand Gulch and Red Canyons.

From 1964 to 1970, 869 cattle were licensed for the winter and 200 cattle during the summer.

In 1971 summer use in Cedar Canyon, Gran Gulch, and Red Canyons was eliminated. Priviledges are now 600 cattle from October 6 to June 5 (4895 AUM's). There is no livestock grazing on the Windgate Mesa, and Red Canyon is now only used as a buffer pasture for 50 cattle every other year from October 6 to February 28.

The White Canyon allotment also created from the old Unit No. 7 had the following use from 1959 to 1961:

1. 1000 cattle, October 15 to May 30 in the White Canyon pasture.
2. 600 cattle, June 1 to January 15 in the Woodenshoe - Deer Flat pasture.

From 1961-1969, there were 950 cattle allowed from October 15 to May 31 in the White Canyon pasture and 300 cattle from June 1 to October 15 in the Woodenshoe - Deer Flat pasture.

Since 1969, priviledges have been 450 cattle from November 1 to October 31, year-round pasture rotation (5544 AUM's). At the present time, 250 cattle graze the White Canyon allotment. Long and gravel canyons are also used during the winter on snow.

The Indian Creek allotment was also created from old Unit No. 7 in 1959. In 1959 the following numbers of cattle were grazed:

1. 300 cattle, May 31 to June 15 in the Beef Basin pasture.
2. 1900 cattle, October 15 to May 30 in the Indian Creek pasture.
3. 100 cattle, June 1 to October 15 in the Cottonwood pasture.
4. 100 cattle, June 1 to October 15 in the Salt Creek pasture.

The present permit is for 150 cattle from November 16 through June 15 in the Beef Basin pasture, 200 cattle from November 16 through June 15 in the Dark Canyon pasture, and 400 cattle from October 16 to April 30 in the Indain Creek pasture. The Beef Basin and Dark Canyon pastures are the only two areas that are within the bighorn study area.

If conflict between the desert bighorn sheep and cattle should occur, it is most likely to happen during the winter and early spring months when sheep and cattle are potentially in close proximity with each other. During the summer months, cattle are removed from prime sheep habitat and taken to summer pastures in the high mountain areas. The complete effects of the livestock grazing on bighorn sheep are not fully known, nor will they be, however, Wilson (1968) and others feel that livestock have had a major impact on the desert sheep populations in Utah through competition for space, alteration of vegetative composition, and introduction of diseases.

Influence of Mining Activities

Mining History

Mining history within the desert bighorn sheep study area began in the 1880's when copper was discovered in the White Canyon area (Chenoweth 1975). Prospecting for copper began as early as 1880 and was very active during 1906 and 1907 at which time the price of copper was high. In 1916 copper ore was shipped from what is now the Happy Jake Mine.

In 1920, B. S. Butler, U.S. geological Survey, identified uranium minerals in the Happy Jack Mine (Chenoweth 1975). The area was essentially inactive until 1948 when the value of uranium was recognized. This brought a tremendous number of people into southeastern Utah all seeking their fortunes in the uranium fields. It is estimated by a local newspaper that at one time there were approximately 10 to 11 thousand people in San Juan County alone (Wilson 1968).

During the period from 1948 to 1974, it is estimated that 1,924,000 tons of uranium ore was produced from approximately 120 properties (BLM records, Monticello, Utah). The most intense activity was during the early 1950's when the Atomic Energy Commission was the main ore buyer. When the AEC stopped it's ore buying program, the uranium "boom" ended. From the later 1960's to the present, the market for uranium was depended on the private use of fuel in nuclear generation of electricity (BLM records, Monticello, Utah).

The price of uranium ore is constantly fluctuating, and at present the price is low. Because of low ore prices, mining in the area has virtually closed. In 1978, 14 mines were active in the study area, however,

with the recent drop in ore prices no mines are presently active. Yearly assessment work (road improvements, etc.) conducted to maintain claims is about all the mining activity in the area.

Mining Effects

Almost all of the known economic uranium - copper ore deposits in southeastern Utah are found in the Chinle formation, specifically the Shinarump member (Figure 3). This is the lower most member of the Chinle formation and consists of coarse grained sediments interbedded with some finer grained beds (Chenoweth 1975). The Shinarump is a fluviatile deposit and fills many channels that were cut into the beds fo the underlying Moenkopi formation, in addition to occurring as a thin deposit at the Chinle base. Almost all of the copper - uranium ore deposits occur in these filled channels. Therefore, the areas where the Shinarump formation is easily accessable have received most of the use by prospectors and miners. These exposed areas of Shinarump are very visable throughout the study area, as are remnants of old mining camps now deserted.

Though the direct effects of past mining activities on bighorn sheep can probably never be effectively evaluated, there is some information available which suggests the impact was quite severe.

Wilson (1968) indicated the large number of people utilizing the area during the uranium "boom" of the 1950's. He also reports that through personal communications he learned that miners often hunted bighorn sheep illegally on days off. He also found bighorn sheep bones and skulls in many old prospector and mine camps.

Irvine (1969) provided some circumstantial but useful evidence concerning mining effects on sheep. He found that of the various geological formations used by sheep, several of the same formations were primary

beds of mineable ore (Figure 3). Thereby suggesting a possible conflict between sheep and miners for sheep and a possible reduction of habitat through mining activities.

McQuivey (1978) reported that the early history of Nevada shows intensive mining activities from 1859-1930. With Nevada's mining boom arose developments which have been identified as possible detriments to the desert sheep populations at that time. Some of the human activities that adversely affected sheep were indiscriminate camping and residency near important water sources, prolonged heavy public use and construction in areas important to sheep, and unrestricted hunting and poaching.

Figure 2 is a map of the distribution of mining sites in the bighorn sheep study area.

Management recommendations with respect to mining in bighorn sheep habitat have been made by the Desert Bighorn Council Technical Staff (1980). Their recommendations suggest that mineral exploration should be rigidly controlled to minimize destruction and insure rehabilitation of habitat. They recommend that agencies in authority should require filing and approval of a developmental and operational plan before premission to procede be given. The plan should also provide for mitigation of impacts to desert bighorn. They also suggested that no water sources be disturbed nor usurped by mineral interest. Critical areas such as lambing grounds, water holes, etc., should be precluded from mining activities.

The current BLM management plan for the desert bighorn sheep area requires the following steps be taken by mining interests:

1. Casual use such as minor surface disturbance is allowed without BLM review.

2. Less then 5 acres disturbance requires that a notice be filed with the BLM.

3. More than 5 acres disturbance requires that a plan of operations be filed, and BLM must complete an environmental assessment and archaeological clearance.

In the past, Utah Power and Light, Minatome, Plateau Resources, and a few other companies have timed their exploratory activities to avoid the lambing season (May 1 to June 15) when operating in crucial bighorn areas. Such voluntary elimination of exploratory activities is thought to have avoided potential conflict between sheep and mining interests.

Influence of Recreational Activities

A complete history of recreation and it's effects on bighorn sheep in Utah is unavailable because of the inaccessibility of the area and the logistics involved in monitoring such a large area. Records of types and intensities of recreational activities and the reaction of bighorn sheep to those activities have not been kept, nor has research been accomplished to determine the extent of human influence on populations of bighorn sheep. The area has been popular for many years with the hikers, backpackers, 4x4 enthusiasts, hunters, river runners, etc. as a recreation area and has received considerable use.

Studies from other states report some data that may be useful in evaluating past influence of recreation on bighorn sheep.

Deforge (1972) reported that a road was constructed through a critical lambing area in the San Gabriel Mountains, California. This road allowed considerable disturbance to sheep from resultant logging, deer hunting, and motorcycle use of the road. These factors were attributed as the cause for sheep leaving areas of historical use.

Dunaway (1970) suggested that increased human use of Inyo National Forest, California had caused a decline in bighorn numbers. He cited examples of reduced sheep use of traditional areas where there was increased human use, and no reduction in sheep numbers where human use had not increased as the basis for his conclusions. He recommended that no new trails be constructed in sheep areas, regulation of human use in critical areas, prevention of recreational developments in sheep habitat, and prohibition of motorized vehicle use on trails.

McQuivey (1978) stated that recreational developments have adversely affected sheep populations in some areas of Nevada. Development of picnic facilities near an important spring used by desert sheep eliminated the area from further sheep use. No sheep have been reported using the water source for several years.

Jorgensen (1974) observed a decrease in utilization of a favored watering site by bighorn sheep on days when the area was frequented by vehicular traffic. He concluded that because sheep and humans used the water during the same time periods, that the sheep were being excluded from the site when people were in the area.

Ferrier (1974) indicated that the recreational development of the Lake Havasu area in Arizona effectively reduced the amount of traditional bighorn sheep habitat along the Colorado River. He also concluded there would be an increased amount of conflict between sheep and recreational activities as human recreation increases.

Hicks and Elder (1972) reported in the Sierra Nevada Mountains, California, that recreationist use of the area had little effect on the distribution of bighorn sheep. The failure of sheep to use areas frequented by people was attributed to poor forage quality rather than human disturbance. They also reported that human - bighorn interactions were rare and had little effect on sheep when they did occur.

Graham (1980) reported that man can recreate bighorn habitat without causing too much disturbance to sheep. Single hikers or occassional groups of hikers had little effect on bighorn herds. Sheep,

though cautious, continued with normal daily activities of feeding, sleeping, playing, etc.. It was noted that if sheep are surprized by hikers (Graham 1980) or if deliberately harassed (Blong 1967), they will flee or even abandon the area.

Weaver (in Graham 1980) commented that in helicopter surveys of the San Gabriel Mountains, California, that they were unable to find bighorn in the vicinity of the trails used by people. Through the season as hiker use increased, bighorn use decreased.

Light (1971) and Graham (1971) measured the effect of human use on bighorn sheep activity, and quantified the amount of human use tolerated by bighorn. The studies showed light to moderate use (0-500 visitor - days/summer season) had little effect on use of bighorn home ranges. Heavy use (500-2000 visitor - days) apparently caused the bighorn to withdraw from their traditional range.

It is generally believed that bighorn will tolerate some disturbance, but continued, frequent, and especially new forms of disturbance cause them to avoid an area.

Vehicular traffic, if steady on through highways or occassionally on remote roads is tolerated by bighorn sheep (Graham 1980), however, sheep are not tolerant of patterns that result in unexpected disturbance.

Motorboats do not apparently disturb bighorn sheep too much. Graham (1980) reported that boats are used for many bighorn surveys and cause little immediate disturbance to sheep as long as the researchers remained in the boats. When the boats landed on shore, bighorn retreated up into rugged cliffs that surrounded the areas. Ferrier (1974) did,

however, report that several key habitats and watering areas were found abandoned by desert bighorn resulting from high concentrations of boat and other associated uses along the Colorado River.

Aircraft, often used to sight-see in bighorn country, apparently have little effect on bighorn sheep. Graham (1980) reported that fixed-wing aircraft that maintain considerable distance above ground have little effect on sheep. However, repeated low level flights do cause bighorn to become spooky. Low flying helicopters often cause considerable panic among bighorn sheep (Bates 1981, Personal Communication).

MacArthur et al. (1979) studied heart rates of free-ranging bighorn sheep. They reported that heart rate, as an indicator of physiological stress, increased significantly when sheep are approached within 200 m by vehicular traffic. Similarly a single pass of a helicopter at 150-200 m illicited a 3.5 fold increase in heart rate of the subject animal. Prolonged human disturbance within 50 m also increased sheep heart rates. Most of the increase took place without any external cues to signify the stressed state. Heart rate responses to transient stimuli usually terminated rapidly, implying that brief disturbances are not particularly costly in terms of energy expended.

The Desert Bighorn Technical Staff (1980) recommended that recreational activities should be eliminated or regulated where they pose a threat to bighorn. Restrictions they suggested include:

1. No camping within ¼ mile of any bighorn watering location.
2. No new hiking trails built through bighorn habitat.
3. Existing trails rerouted away from critical areas.

4. The number of people allowed in key areas limited either on a seasonal or permanent basis.

5. Boat use disturbing to bighorn sheep should be prohibited.

6. Use of aircraft within 500 feet of the ground over bighorn habitat should be limited to administrative purposes only.

7. Crucial use areas should be closed to off-road vehicles, and vehicular traffic should be limited to designated areas only.

They also suggest that the presence of people in bighorn habitat may not necessarily have an adverse impact on desert bighorn populations, but rather is more dependent on the type, duration, intensity, and period of use.

Hunting has been imposed on desert bighorn throughout the western United States. Although animals are removed from the population, the hunts are generally trophy hunts designed to harvest only mature rams. The effects of trophy hunting are not completely understood but most bighorn managers agree that if conducted properly, surplus rams can be harvested without damaging the sheep population (McQuivey 1978).

Hunting in Utah began in 1967. Since that time the desert bighorn has been hunted every year, with the exception of 1974 and 1975 when the hunt was concelled to protect radio-collared rams being studied by the Utah Division of Widlife Resources. The history of the number of applicants, hunters, and successes is presented in Table 2.

Physiological and Disease Information

Parasitic Diseases

Scabies ear mites (Psoroptes sp.) have been indicated as partially responsible for declines in mountain sheep numbers in several states including California, Idaho, Nevada, and New Mexico (Jones 1950, Smith 1954, Cater 1968, Lange 1980, Lange et al. 1980, deVos et al. 1980). Beuchner (1960) found that mortalities caused by scabies were known to have reduced bighorn populations at the time domestic sheep were first introduced to this country.

Scabies are obligate parasites that attach themselves externally to various sheep body parts, particularly the ears. The mite sucks out and consumes lymph cell serum, and even erythrocytes. Ear lesions area characterized by yellow-white raised epidermis and crusted serous exudate bearing hairs from follicles (Lange et al. 1980). Though not directly fatal, the indirect results caused by mites may lead to poor condition and eventual death. Painful ear lesions may prevent normal feeding habits, leading to weight loss and decline in condition. A loss of insulative outer body hair may also result from scabies infestations. Mites in small numbers are generally no harm to the sheep, but it is possible for mites to overrun ears and spread out to the neck, head, and back increasing to numbers capable of destroying the symbiotic equilibrium between sheep and mites resulting in the death of the sheep (Meleney 1981, personal communication).

Sandoval (1980) reported that in New Mexico three treatments for controlling scabies mites in free ranging sheep had been evaluated. Coumaphas dust bugs suspended over salt blocks, dipping into asaricidal dip

(toxaphene) and confinement, and on-range innoculation from a helicopter using basllistic implants and a compressed-air rifle delivery system were all tested. Only the compressed-air rifle innoculation with 400 micrograms/ Kgm of ivermectin was successful with acceptable mortality rates.

Lungworm (Protostrongylus sp.) has been identified in many bighorn populations in several states (Honess and Frost 1942, Pillmore 1958, Allen 1964, Taylor 1976). Particularly severe losses of bighorn sheep have been attributed to longworm infestation and the associated bacterial invasion-caused pneumonia (Hibler 1974, 1975) in Colorado and North Dakota herds.

McQuivey (1978) indicates that although lungworm is found in Nevada, it is limited to those sheep populations occupying higher elevations where tree cover and duff are present. Sheep that inhabit lower elevations in desert shrub communities do not have lungworm. Those populations that are infected by lungworm have not shown any declines to the present.

Wilson (1968) also concluded the lack of lungworm in Utah sheep was a result of the dry desert shrub communities being unable to support the terrestrial snails that are obligate intermediate hosts for lungworm larvae.

Lungworm can have especially severe effects on lamb survival (Spraker 1977). It was documented recently (Kistner and Wyse 1979) that transplacental transmission of Protostrongylus sp. may occur between dam and fetus causing respiratory abnormalities to develop in the growing fetus and newborn lambs. To combat this problem Hibler et al. (1977) and Schmidt et al. (1979) developed a treatment for lungworm in bighorn sheep. They found that lamb mortality was reduced significantly

if pregnant ewes were treated with Cambendazole and Fenbendazale (antihelminthic drugs). Treatment of free-ranging sheep was facilitated by mixing the drug dose in apple mash and distributed over sheep range.

Bunch et al. (1978a) and Bunch et al. (1978b) have described a potentially serious disease, chronic sinusitis, that infects bighorn sheep. Sinusitis has been thought to be responsible for the decimation of the Zion National Park herd of desert bighorn and also has been found in considerable numbers of sheep in Arizona, Nevada, and California (Bunch and Webb 1979, Bunch 1980). Symptoms of the disease include poor physical condition, draining lesions in the nasal and frontal regions of the skull, osteolysis of the horn core and brain case, and eventual death (Bunch 1979).

The exact cause, though thought to be associated with viral infection secondary to necrotic nasal bot fly larvae, is still unknown. Because the early diagnosis of the disease is not yet possible, and sheep in advanced stages of the disease fail to recover and eventually die, chronic sinusitis is potentially dangerous to free-ranging bighorn sheep populations in Utah.

In 1979 a dead ewe was found in the Blue Canyon area of southeastern Utah. Death was apparently the result of advanced sinusitis as evidenced by numerous draining lesions on the nasal sinus region and extremely poor body condition. Since then no other sheep with sinusitis have been reported from the bighorn study area. Bates (1981, personal communication) has reported several cases of sinusitis

in Canyonlands National Park, Utah, which is immediately north of the BLM bighorn study area.

Wilson (1968) found that 87% of Utah desert sheep fecal samples were negative for parasites. The 13% that were infected did not contain significant numbers of eggs, proglottids, larvae, etc. to indicate that parasitism was a decimating factor in Utah bighorn sheep herds. The parasites that have been identified in Utah sheep were intestinal parasites and scabies mites (Wilson 1968, Irvine 1969).

A comprehensive list of parasites reported from desert bighorn sheep has been published by Allen (1980).

Bacterial Diseases

Respiratory problems other than those associated with lungworm have been noted by several researchers. Russo (1956) reported observation heavy mucous discharge from the nostrils of several Arizona sheep. Seizures of spasmodic coughing and gagging were also observed frequently.

Welles and Welles (1961) indicated that severe coughing accompanied by swollen eyes and considerable lethargy were common for bighorn lambs in Death Valley.

Helvie and Smith (1970) concluded after 49 necropsies of desert bighorn sheep from the Desert game Range, Nevada, that the major cause of death was pneumonia resulting from infections of Pasturella and Cornybacterium organisms.

Taylor (1976) also working with Nevada sheep suggested that Pasturella hemolytica- caused pneumonia is a significant cause of mortality in desert bighorn lambs. He also suggested that pneumonia probably serves to regulate populations to the available food and water supply.

Spraker (1977) also concluded that fibrinous pneumonia was one of the most important diseases of captive bighorn sheep. The acuteness of the disease being derived from captivity imposed stress allowing the sheep to become susceptible to Pasturella.

Wilson (1968) reported that a necropsy of a sacrificed free-ranging ewe from southeastern Utah showed abnormally small lungs that completely adhered to the body wall and diaphragm indicating that the ewe had previously suffered from severe pneumonia. He also observed young lambs with rough coats, abnormal feeding habits, and coughing izures which he attributed to severe pneumonia. Wilson considered the relatively high lamb mortality in his area due to pneumonia. He attributed the high susceptibility of

lambs to poor range conditions.

Other bacterial caused problems have been associated with organisms of the genus Actinomyces. Malformation of bones and skulls are related to infections by these bacteria (Allen 1980).

Viral Diseases

Few viral diseases have been detected in desert bighorn sheep. Hailey (1966) reported that a lamb had died of blue tongue, a viral-caused infection found in cattle and domestic sheep. The virus is transmitted by biting midges and causes local inflammation, necrosis of mouth and tongue, and scab formation on the lips and nostrils (Allen 1980).

Brucellosis and leptospirosis have been suspected of occurring in bighorn sheep, but there has been no supporting evidence. All tests conducted in Arizona, New Mexico, and Nevada were negative (Allen 1980).

STUDY METHODS

Description of Study Area

Immediately south of Canyonlands National Park in southeastern Utah, the Bureau of Land Management administers extensive acreages of public land that provide suitable habitat for desert bighorn sheep. The bighorn sheep study area proper (Figure 4) is encompassed by the following boundries:

1. South Boundry - south rim of Red Canyon, Utah Highway 263
2. East Boundry - Manti - LaSal National Forest.
3. North Boundry - Canyonlands National Park.
4. West Boundry - Glen Canyon National Recreational Area.

The study area is composed some of the most rugged desert terrain found anywhere in the United states. Topography throughout the area is rough and broken. Canyons are very preciptous and not easily accessible to human use. Talus slopes and boulders are common throughout the canyons, with many slopes exceeding 100% grades.

The topography within the area varies considerably from region to region. The southern region of the study area (Red Canyon, White Canyon, Jacobs Chair) are characterized by high mesas and buttes of sandstone cliffs and talus slopes rising as much as 2000 feet from rough broken canyon bottoms. The northern region (Dark Canyon,Bowdie Canyon, Gypsum Canyon), though in rather close proximity, is contrastingly different in structure. Most striking about the northern region are the extremely deep, Precipitous gorges falling as much as 1500 feet from the rim tops to the Colorado River and it's tributaries.

The soils of the area are usually shallow and not well developed.

Plant communities in the study area are typical of the Upper and Lower Sonoran Life Zones. Common communities found in the study area include: (1) blackbrush - galleta, on many of the canyon slopes and benches, (2) shadscale - galleta - ephedra, common in many areas with south facing slopes and benches, (3) pinyon - juniper, found on mesa and rim tops throughout the study area, and (4) salina wild rye - galleta, on north or west facing slopes. Occassionally, junipers and other shrubs from the pinyon-juniper community are found on talus slopes and benches. Vegetation is usually sparse, but during years of good rainfall, plant production is greatly increased.

Temperatures range from 0^{o} to $40^{o}C$ throughout the year, and the average annual precipitation is generally less than 23 cm.

Procedures

In order to accurately determine overall movements and habitat selection of desert bighorn sheep, 7 animals (2 adult ewes, 2 ram lambs, and 3 yearling rams) were captured by the Utah Division of Wildlife Resources biologists and fitted with Telonics radio transmitters in February 1981. Sheep were tranquilized from a Hughs 500 D helicopter with M99 (Etorphine). After the radio-collars were attached, the sheep were administered M50-50 (Diprenorphine), a reversal drug to the M99, and released. Since that time, monthly fixed-wing aircraft flights have been made with the UDWR to track sheep movements. Also each sheep was located bi-weekly from the ground when possible in order to more accurately determine movements and habitat selection. All locations of collared sheep were recorded on U.S.G.S. 15 minute topographic maps. Home range size was determined by using radio-locations plotted on the map and estimating the total area with a planimeter.

Habitat utilization was determined by recording aspect, topographic type, and vegetation type each time a sheep was observed. These data were not analyzed statistically because of the limited number of observations of sheep during the first three months of the study.

Forage utilization by desert bighorn sheep was determined by recording frequencies of use of different plant species at various feeding sites. Use of a culm of grass, leaf or stem of a forb, or leader or leaves of a shrub or tree constituted one instance of use. (Lauer and Peek 1976). Instance of use was recorded for each sheep in the group in rotation for as long as the sheep could be observed feeding. Forage was recorded as to one of three classes of forage

including grass, forbs, and shrubs. When possible, species of plant being eaten was also recorded. Fecal samples were collected by BLM personnel for winter and spring 1980 and analyzed by Colorado State University. Fecal samples were also collected by the researcher for summer 1981 but have yet to be analyzed.

Since field work began the first week of June 1980, after livestock had been removed from areas potentially utilized by bighorn sheep, evaluation of livestock influence on bighorn sheep behavior has not been possible. Livestock distribution in relationship to bighorn sheep distribution has been plotted (Figure 2).

Mining activity in the area has been very rare since field work began in June. As a result, no observations of sheep interactions with mining activities have been possible. Sheep distribution in relationship to mining activities has been plotted (Figure 2).

Influence of recreation on bighorn has also been difficult because of the relatively few observable encounters between recreationists and sheep. The influence has been evaluated in terms of sheep reaction with respect to the following variables each time the researcher observed an interaction between sheep and recreationists:

1. Group classification; ewes, ewes and lambs, rams, or rams, ewes and and lambs together.
2. Group size; single animals, animals in groups of 2 to 7, and groups of animals greater than 7 individuals.
3. Distance to disturbance; close - 0 to 75 yds., medium - 75 to 300 yds., and far - greater than 300 yds.
4. Type of disturbance; hiker, vehicle, plane, and boat.

The response of sheep to the above variable was recorded as being

Light - little to no reaction to disturbance, Moderate - casual movement away from area, Extreme - hurried flight away from the disturbance. Evaluation of these variables will also apply to livestock and mining activities as well as other human activities, as sheep probably cannot discriminate between recreational mining, and livestock participation in activities on foot or by vehicle.

Due to the small sample size, the data were not analyzed statistically.

Physiological and disease information was collected by the federal veterinarian who accompanied the UDWR personnel during the transplant and capture operations that occurred in November 1980 and February 1981. Blood samples were collected and analyzed to determine if sheep were infected with Brucellosis, Leptosporosis, Anaplasmosis, and Blue Tongue diseases. Sheep were also examined externally to determine if sheep were infected by external parasites and chronic sinusitis.

RESULTS

Movements

Ram #148.065, a 1½ year old when collared February 14, 1981, was captured on the north side of Jacobs Chair Mesa. This young ram was located 16 times from February until September 1981. He was always found in association with 3 mature ewes and 3 lambs. The young ram, along with these sheep, used the Jacobs Chair Mesa area all summer long. The home range calculated for ram #148.065 was 1.56 sq. mi. (Figure 5). The sheep were located primarily on the Chinle talus, however, they were located in the blackbrush-galleta flats below the mesa on two occassions. They were also observed to use the mossback formation flats below the Chinle talus on two occassions.

Ram #148.075, also 1½ years old when captured, was collared on the southeast facing slope at the head of Mahon Canyon February 13, 1981. Ram #148.075 was located ten times from February to September 1981. He was associated with 2 yearling rams and 5 ewes and yearling ewes. His home range was 2.96 sq. mi. (Figure 5). These sheep were only seen using talus slopes, but were observed or located in Mahon, Rainbow and Wilson Canyons which would require considerable movement to move between canyons.

Ram #148.085, a 1½ year old, was captured and collared in Cataract Canyon. He was located 7 times from February until September. This ram moved more than any of the other collared sheep. He moved from Cataract Canyon into Dark Canyon, then into the head of Bowdie Canyon, back down into Dark Canyon, and then into Lean-to Canyon.

His home range was calculated to be 8.96 sq. mi. (Figure 5). On September 18, 1981 ram #148.085 was found dead in Lean-to Canyon. The sheep had been killed by a cougar 3-4 days prior, and was almost entirely consumed when the sheep was located.

Ram #148.135, a lamb when collared, was captured in Rainbow Canyon. Ram #148.075 was in the group when he was captured. This young ram was located 14 times from February to September 1981. His home range was calculated to be 5.84 sq. mi. (Figure 5). Ram #148.135 was seen in close association with ewes and lambs and also with young rams. He moved considerably being captured in Rainbow Canyon, into Mahon Canyon, into Hidden Valley, and also Blue Notch Canyons. This ram was observed to use primarily talus slopes and benches of the Chinle formation.

Ram #148.155, a lamb, was collared in Dark Canyon, near it's mouth. This ram was only located 7 times because of the ruggedness of the terrain. He was very static in his movements, only using the Dark Canyon area, until September when he was located in Sheep Canyon with 5 mature ewes and 5 lambs. These sheep used the talus slopes above Lake Powell and were often seen at the lake watering. His home range size was calculated to be 4.16 square miles (Figure 5).

Ewe #148.115, a young ewe, was collared in Mahon Canyon. This ewe remained in Mahon Canyon exclusively from February until September 1981. Her home range size was calculated to be 1.28 sq. miles (Figure 5). She utilized the talus slopes and benches on both east and west faces of the canyon. She was always observed alone; no lamb was ever observed with her. She was located 9 times.

Ewe #148.145, a mature ewe, was collared in Blue Notch Canyon. She was very active in her movements, moving from Blue Notch Canyon to the head of Mahon Canyon, then into Hidden Valley where she had her lamb, back to Blue Notch, over into Scorup Canyon and back again into Blue Notch Canyon. Her home range was calculated to be 5.88 sq. miles (Figure 5). She was observed usually in the presence of several other ewes, lambs, and young rams. The group size was generally 13, but varied from 3 to 16. These sheep primarily used the talus slopes and benches just under the Windgate sandstone. Ram #148.135 was observed in association with ewe #148.145 on 4 separate occassions. She was located 15 times from February to September. Home range data for all collared sheep are summarized in Table 3. Distance moved between monthly fixed-wing flights and average monthly distance moved by collared sheep are summarized in Table 4.

Habitat selection was evaluated in terms of vegetation type, aspect, and topographic type. Each time a sheep was observed the above variables were recorded. The most often utilized vegetation type was the shadescale-ephedra-galleta type; 55.0% of all sheep were observed in this type (222 observations). The most selected aspect was the south-facing slope; 33.8% of all sheep were observed utilizing south-facing slopes (210 observations). The most selected topographical type was the talus slope; 60.8% of all observations of sheep were on talus slopes (222 observations). Data are summarized in Tables 5,6,7.

Forage Utilization

Feeding habits data were collected by BLM personnel for the winter and spring of 1980. Fecal samples were collected and sent to Colorado State University where they were analyzed. Results showed that during winter and spring , shrub species were most often selected (Winter 1980 - 76.4% shrub, spring 1980 - 61.3% shrubs), and grasses and forbs were used significantly less (Table 8).

Feeding habits based on feeding instances were observed by the researcher from July 14 - September 14, 1981. Similar results to BLM findings were found. Sheep used shrub species primarily (76.0%) and secondarily grasses (18.3%) and forbs (5.7%) (Table 9).

The most selected plant species were Cliffrose (*Cowania mexicana*), blackbrush, shadescale, and galleta grass (Table 10).

Influence of Recreation

Recreational activities in the study area are spread out through time and space. Because recreation activities are not restricted on BLM lands, accurate records of types of activity, season of use, and intensity are not available. However, backpacking, hiking, rock hounding, pine-nut gathering, 4x4 touring, hunting, etc., all take place within the BLM desert bighorn sheep study area (Figure 7).

The National Park Service does, however, keep records of activities within Canyonalnds National Park. Some of these activities extend into the BLM study area and can be used as a partial indicator of uses of BLM land within the study area.

National Park Service records (Moab, Utah) indicate activities of several outdoor leadership groups and river running outfitters extend into bighorn sheep habitat (Table 12). From 1978-1981 the general use trend of BLM lands by outdoor leadership groups has increased both in number of people and days of use in the area. Commercial and private parties also increased their use of the Colorado River from 1976-1980 (Table 12). Complete data are not available for 1981, however, it appears that the use figures for 1981 will surpass previous years.

The bighorn sheep hunt was held from September 12 to October 11, 1981. Eighteen permits were issued for three hunting units. Ten permits were issued for the North San Juan Unit, five permits were issued for the South San Juan Unit, and two permits were issued for the Potash Unit (Figure 6). One special permit was sold for $22,000. The successful applicant for this permit has the priviledge of hunting in any of the three units.

Only the North and South San Juan Units are within the BLM bighorn study area. Five hunters were successful in taking their rams; four sheep were harvested from the South Unit and one from the North Unit.

Recreational activities as well as other human influences were also evaluated by looking at the response between sheep and human disturbance with respect to sheep group size, sheep group composition, sheep distance to disturbance, and type of disturbance. Because of the relatively small sample sizes to this point, data were not statistically analyzed. However, from the data, Table 13, it can be generalized that sheep of medium sized groups of ewes, lambs, and rams are little affected by boat travel along the river regardless of the distance. The sheep are away from the boat. It appears that sheep, regardless of group size or composition, are little affected by plane traffic if the planes fly relatively high. If, on the other hand, aircraft fly low to the ground, responses are extreme causing flight by the sheep (Table 13).

It appears from the limited number of observed interaction between sheep and vehicle traffic (11) that regardless of group size, group classification, and distance to disturbance, that interactions between sheep and vehicles are not serious enough to cause more than a light response. In only one case did a vehicle-sheep interaction result in a hurried escape by the sheep. That occurred when the vehicle approached the sheep to within 75 yds. (Table 13).

Response to hikers by sheep is somewhat more complicated. The

data are less clear as to the influence of humans. It would appear superficially, however, that hiking is somewhat more disturbing to sheep than the other types of diturbance. Solitary animals all exhibited extreme response to hikers regardless of distance to disturbance (all solitary animals observed interacting with hikers were ewes). Medium sized groups that interacted with hikers responded extremely to hikers only at close and moderate distances. These extreme reactions comprised 33% (7 of 21) of the responses of medium sized groups to hikers at close to medium distances. Sixty-seven percent of interactions (14 of 21) of medium sized groups at close to medium distances show moderate to little reaction. Medium sized groups disturbed by hikers at long distances showed little response. Large groups of sheep responded extremely at close distances one time and moderately at close distances once, and moderately at medium distances twice; no apparent pattern. Generally speaking, larger groups are probably disturbed less by hikers at close to medium distances than are smaller groups (Table 13).

Disease Information

During the Utah Division of Wildlife Resources bighorn sheep transplant operations in November 1980 and February 1981 blood samples were collected from a total of 32 sheep. Sheep that were collared for the BLM bighorn study were also bled. Fourteen sheep were tested in November 1980 for Brucellosis only. All 14 sheep were negative for Brucellosis. In February 1981, 18 sheep were bled. Blood samples were analyzed for Brucellosis, Leptospirosis, Anaplasmosis, and Blue tongue disease. Sheep proved negative for all diseases except for Blue tongue disease.

Four of the 18 sheep bled showed titers for the disease, however, no sheep showed clinical signs of Blue tongue. The sheep have been exposed to the virus at some time and have developed an immunity to it.

During capture and transplant operations, two yearling rams were captured that were infested mildly with scabies mites. The sheep were apparently in good physical condition and were not seriously affected by the mites. No other sheep have been observed with ear mite problems.

No sheep captured during the transplant or collaring operations showed any symptoms of desert bighorn chronic sinusitis nor have any infected sheep been observed in the field since June 1981.

DISCUSSION AND RECOMMENDATIONS

The first few months of field work (June - September 1981) have been spent by the researcher in becoming familiar with the sheep and the area. Information collected to this point, though useful, is based on sample sizes too small to justify statistical analyses. Therefore, conclusions have been formulated by scanning data for obvious patterns. As the study progresses and more data become available, statistical analyses will be the basis for all conclusions and recommendations.

The movements of collared sheep during the first few months of the study have been limited to rather small home ranges. This can be attributed partially to several factors. Ewes and young rams are the only sheep collared, and they historically have smaller home ranges and move less than older rams. There has also been a extraordinarily large amount of rainfall this summer which has stimulated plant productivity. Forage conditions have been extremely good all summer long. Also, as a result of the rain, water is available at many natural seeps, springs, and rock tanks throughout the study area. Sheep have not had to move great distances for food or water.

It is necessary to fully understand sheep movements that they continue to be monitored throughout the next few years. It is also necessary that more sheep be collared, including some older rams. Very little is known about the home range size of large rams in the study area and should be a primary concern of the study.

Habitat utilization must also be continually monitored in order to better comprehend the scope of the problem. During summer months,

a majority of sheep were observed utilizing the talus slopes and benches of the Chinle formation. This should be kept in mind when formulating management plans for the area. Talus slopes and benches should be protected from extreme use by all activities that would potentially interfere with normal sheep behavior. It should be noted also that preferred vegetation types and slope exposure should be protected from disturbances.

The summer food habits of the desert sheep of the BLM bighorn study area are apparently different from sheep in other areas. The sheep selected a higher percentage of browse than sheep in other areas. This is partially attributable to the good rainfall conditions that stimulated good plant productivity and to the dominance of browse species in desert bighorn habitats. A detailed vegetative analysis should be conducted to determine if sheep are selecting browse proportionate to the percentage of browse in the plant communities. This will enable determination of forage preferences by bighorn sheep and will determine if sheep are generalist or specialist foragers.

To this point, information concerning recreation and it's effects on bighorn sheep is limited. Interactions between sheep and recreationists are relatively few, however, if the trend of activity during the spring and fall months increases and the area of activity expands deeper into bighorn habitat, some problems during lambing and breeding seasons may occur. Intensity of recreationist activity should be monitored closely, as well as season of use and specific areas receiving most traffic.

Interactions between cattle and bighorn sheep have not been possible yet, but this fall and winter when cattle and sheep use areas will

overlap, observations will be made to determine cattle feeding habits and characteristics of cattle habitat. These data will be compared with those of desert bighorn sheep to determine if significant niche overlap exists between the two species.

Mining influence at present is difficult to asses due to the lack of activity within the study area. It does seem important to encourage future cooperation between mining interests and resource managers in delaying exploration, mining, and assessment activities to periods that do not overlap with lambing or breeding seasons. This would prevent an influx of activity into bighorn habitat during critical periods.

Diesease information needs to be continually collected whenever possible. With the chronic sinusitis problem in the Canyonlands National Park herd not too distant from BLM desert sheep, a close watch should be kept to determine if such a problem arises. It is also important to keep a close watch on the frequency of occurrence of scabies mites and blue tongue disease in sheep. Both are potentially lethal and could impose considerable mortality losses on bighorn populations.

It is also important that the number of predators and their effects on bighorn sheep populations be determined. Ram #148.085, a two year old, was killed by a cougar mid September 1981. Since then, three more cougar-killed sheep have been located. Hunters and backpackers in the North San Juan hunting unit located a two year old ram and 2 four or five year old rams thought to have been killed by cougars. Cougars could have a significant effect on bighorn populations, especially if bighorn numbers are low and alternate prey for the lions is relatively unavailable. Surveys

to determine cougar populations would be extremely helpful in assessing factors reducing bighorn numbers on BLM managed land.

Problems during the study have been minimal. The only major problem experienced was the failure to capture and collar ten bighorn. This was primarily a result of low sheep numbers. Utah Division of Wildlife Resources personnel could not find enough sheep in the time allotted by the project budget. Helicopter time is continually increasing in price, and increases from the time the project was budgeted and the time the actual capture operations were carried out severely limited flying time.

Another problem that has been experienced is covering the entire study area adequately. The study area is extremely large and the terrain is very rugged. This has resulted in activities being primarily limited to the areas in the general vicinities of the collared sheep. The majority of the work has been limited to the southern half of the area. If intensive research is to be conducted, the scope of the study must be restricted to the areas where collared sheep spend a majority of their time.

The only problem anticipated is being able to capture and collar more sheep. It seems important, to get an accurate picture of sheep movement and habitat utilization, to capture and collar a few adult rams and more mature ewes. Without this information, serious restrictions will be placed on management decisions due to the lack of important information.

Relationships with all agencies involved in the study (Bureau of

Land Management, Utah Division of Widlife Resources, U.S. Forest Service, and National Park Service) have been very cordial. All have actively participated in making the study as trouble-free as possible.

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Appendix

Tables

Figures

Photographs

TABLES

Table 1. Forage utilization of desert bighorn sheep in southeastern Utah (Wilson 1968).

Plant	Minutes per plant	Per cent of total
Grasses		
Hilaria jamesii	338.0	25.2
Oryzopsis hymenoides	125.0	9.3
Elymus salina	48.5	3.6
Bromus tectorum	14.5	1.1
Stipa speciosa	1.0	0.1
Total for grasses	427.0	39.3
Browse		
Coleogyne ramosissima	258.0	19.2
Fraxinus anomala	207.0	15.4
Symphoricarpos longiflorus	48.0	3.6
Ephedra sp.	39.0	2.9
Cowania mexicana	25.0	1.6
Atriplex canescens	3.0	0.2
Pinus edulis	2.0	0.2
Tamarix gallica	2.0	0.2
Atriplex confertifolia	2.0	0.2
Juniperus osteosperma	1.5	0.1
Salix sp.	1.0	0.1
Artemisia spinescens	1.0	0.1
Shepherdia rotundifolia	1.0	0.1
Dalea thompsonae	1.0	0.1
Chrysothamnus sp.	0.5	t[a]
Total for browse	592.0	44.1
Forbs		
Salsola kali	110.0	8.2
Bassia hysopifolia	73.0	5.4
Unidentified forbs	26.0	1.9
Hymenoxis richardsonii	10.5	0.8
Kochia americana	1.0	0.1
Streptanthus arizonicus	1.0	0.1
Gutierrezia microcephala	1.0	0.1
Calochortus nuttallii	0.5	t[a]
Total for forbs	223.0	16.6
Grand total	1342.0	100.0

[a] t=value of less than 0.1 per cent

Table 2. Yearly summary of Utah's desert bighorn sheep harvest.

Year	Permit Applications	Ram Permits Sold	Hunters Afield	No. of Hunter Days	Ram Harvest	% Succ.
1967	432	10	9	24	9	100
1968	404	10	10	52	3	30
1969	447	10	10	55	6	60
1970	516	10	10	74	4	40
1971	477	10	10	—	1	10
1972	478	10	8	—	1	12
1973	No Hunt					
1974	No Hunt					
1975	147*	5	5	31	2	40
1976	204	10	10	87	4	40
1977	326	25	25	226	10	40
1978**						
Nonresident	7	3	3	46	1	33
Resident	323	20	20	151	6	30
1979**						
Nonresident	43	1	1	21	1	100
Resident	397	17	17	214	2	12
1980	—	18	18	—	10	55
Totals	4300	159	156	981	60	38

*Beginning in 1975, the permit fee was increased to $100 and had to accompany each application.

**Beginning in 1978, nonresident permits were available.

1979 Utah desert bighorn harvest

Unit	Number of Applications		Applications Per Permit		Number of Permits	
	Res.	Nonres.	Res.	Nonres.	Res.	Nonres.
North San Juan	248	43	25	43	10	1
South San Juan	119	0	24	0	5	0
Potash	30	0	15	0	2	0

Data from Utah Big Game Harvest Book

Table 3. Sex, ages, home range size, and number of radio-locations of collared sheep.

No.	Sex	Age	No. of locations	Home range size /sq. mi.
148.065	M	1½	16	1.56
148.075	M	1½	10	2.96
148.085	M	1½	7	8.96
148.135	M	lamb	14	5.84
148.155	M	lamb	7	4.16
148.115	F	mature	9	1.28
148.145	F	mature	15	5.88

Table 4. Distance moved by collared bighorn sheep between monthly fixed-wing telemetry flights (1981).

No.	Sex	Age	Months	Distance Moved (mi.)	Average (mi.)
148.065	M	1½	Feb.-May	.50	
			May -June	.25	
			June-July	.75	
			July-Aug.	2.00	
			Aug.-Sept.	1.00	
			Sept.-Oct.	.25	.80
148.075	M	1½	Feb.-May	2.75	
			May-June	2.00	
			June-July	1.00	
			July-Aug.	2.50	
			Aug.-Sept.	2.00	
			Sept.-Oct.	1.50	1.96
148.085	M	1½	Feb.-May	4.00	
			May-June	6.50	
			June-July	5.75	
			July-Aug.	1.75	
			Aug.-Sept.	4.75	4.55
			Sept.-Oct.	dead	
148.135	M	lamb	Feb.-May	1.00	
			May-June	2.00	

Table 5. Desert bighorn sheep use of vegetation types.

Vegetation type	No. of sheep observed	Percent of total
Pinyon-juniper	24	10.8
Blackbrush-galleta	55	24.8
Shadscale-ephedra-galleta	122	55.0
Galleta-saline wild rye	21	9.4
TOTAL	222	100.0

Table 4. (cont.)

No.	Sex	Age	Months	Distance Moved (mi.)	Average (mi.)
			June-July	2.50	
			July-Aug.	2.50	
			Aug.-Sept.	.75	
			Sept.-Oct.	4.25	2.17
148.155	M	lamb	Feb.-May	.75	
			May-June	1.25	
			June-July	.50	
			July-Aug.	5.50	
			Aug.-Sept.	.75	
			Sept.-Oct.	.50	1.55
148.115	F	mature	Feb.-May	4.00	
			May-June	4.00	
			June-July	1.25	
			July-Aug.	2.50	
			Aug.-Sept.	3.00	
			Sept.-Oct.	2.00	2.79
148.145	F	mature	Feb.-May	1.00	
			May-June	1.00	
			June-July	2.00	
			July-Aug.	.50	
			Aug.-Sept.	1.00	
			Sept.-Oct.	1.50	1.17

Table 6. Desert bighorn sheep use of slope aspects.

Aspect	No. sheep observed	Percent of total
North-facing	21	10.0
South-facing	71	33.8
East-facing	44	21.0
West-facing	31	14.8
Southeast-facing	24	11.4
Southwest-facing	19	9.0
Northeast-facing	0	0
Northwest-facing	0	0
Total	210	100.0

Table 7. Desert bighorn sheep use of topgraphic types.

Topographic types	No. sheep observed	Percent of total
Talus slopes	135	60.8
Benches	56	25.2
Mesa top	15	6.8
Valley floor	16	7.2
Total	222	100.0

Table 8. Diet composition of desert bighorn sheep in southeastern Utah, 1980. (BLM Fecal samples). *

Forage class	Percent of total	
	Winter	Spring
Grass	5.2	29.0
Shrubs	76.4	61.3
Forbs	18.2	10.7
Totals	100.0	100.0

* A complete breakdown of major plant species selected by desert bighorn sheep as determined by BLM fecal analysis is available at BLM office, Monticello, Utah.

Table 9. Summer diet composition of desert bighorn sheep in southeastern Utah, 1981 (direct observation of 600 feeding instances).

Forage Class	No. Feeding instances	Percent of total
Grass	110	18.3
Shrubs	456	76.0
Forbs	34	5.7
Totals	600	100.0

Table 10. Plant species selected by desert bighorn sheep in southeastern Utah, Summer 1981.

Plant species	No. Feeding instances	Percent of total
Cliffrose	196	32.7
Blackbrush	139	23.2
Shadscale	95	15.8
Galleta grass	43	7.1
Skunkbrush	41	6.8
All others	86	14.3
Totals	600	100.0

Table 11. Outdoor leadership group use of BLM lands within the bighorn sheep study area. (1978-1981)
1978

Group	Dates	No. of people	Areas
Nat. Outdoor Leadership School	2/20-26	46	Beef Basin, Gypsum Canyon, Cross Canyon, Pappy's Pasture, Middle Park, Homewater.
Nat. Outdoor Leadership school	3/5-9	46	Beef Basin, Gypsum Canyon, Cross Canyon, Pappy's Pasture, Homewater, Middle Park.
Colorado Outward Bound School	9/10-22	43	Beef Basin, Calf Canyon, Ruin Canyon, Poison Canyon, Trail Canyon, Dark Canyon, young's Canyon, Sweet Alice, Butler Wash, Fable Valley, House Park.
Colorado Outward Bound School	10/12-22	43	Poison Canyon, Dark Canyon, Black Steer Canyon, Young's Canyon, Sweet Alice, Beef Basin.
Colorado Outward Bound School	10/18-22	32	Ruin Park, Young's Canyon, Beef Basin, Butler Wash, Cross Canyon.
Nat. Outdoor Leadership School	11/22-25	80	Gypsum Canyon, Imperial Valley, Sweet Alice, Pappy's Pasture, Ruin Park, Butler Wash, Wild cow point, Middle Park.
	43	290	

Table 11 (cont.)
1979

Group	Dates	No. of people	Areas
Nat. Outdoor Leadership School	3/3-14	40	Bobby's Hole, Home Spring, Fable Valley, Sweet Alice Canyon, House Park Butte, Ruin Park, Beef Basin, Butler Wash.
Colorado Outward Bound School	5/7-18	43	Beef Basin, Fable Valley, Young's Canyon, Dark Canyon, Sweet Alice, Ruin Canyon, Poison Canyon, Trail Canyon.
Colorado Outward Bound School	10/18-25	39	Dark Canyon, Sweet Alice.
Nat. Outdoor Leadership School	11/23-29	40	Cross Canyon, Butler Wash, Bull Valley, Imperial Valley.
	43	290	

Table 11 (cont.)
1980

Group	Dates	No. of people	Areas
Nat. Outdoor Leadership School	2/28-3/13	20	Butler Wash, Bobby's Hole, Sweet Alice Canyon, Fable Valley, Beef Basin, Ruin Park, Imperial Valley.
Nat. Outdoor Leadership School	3/1-14	20	Cross Canyon, Bobby's Hole, Bull Valley, Beef Basin, Ruin Park, House Park Butte.
Vision Quest	4/21-29	13	Beef Basin, House Park, Butler Wash, Cross Canyon.
Colorado Outward Bound School	5/9-21	42	Fable Valley, Young's Canyon, Dark Canyon, Cross Canyon, Ruin Canyon, Nail Canyon, Beef Basin, Sweet Alice, Butler Wash, Poison Canyon.
Colorado Outward Bound School	9/18-27	48	Dark Canyon, Young's Canyon, Lean-to Canyon, Dark Canyon Plareau, Sweet Alice Springs.
Colorado Outward Bound School	10/16-25	48	Dark Canyon, Young's Canyon, Lean-to Canyon, Dark Canyon Plateau, Sweet Alice Springs.
Nat. Outdoor Leadership School	11/23-28	40	Beef Basin, Sweet Alice Canyon, Butler Wash, Starvation Pocket.

Table 11 (cont.)
1980

Group	Dates	No. of people	Areas
Enviros	12/12-22	14	Butler Wash, Beef Basin, Gypsum Canyon, Fable Valley, Ruin Park, Bobby's Hole.
	87	245	

Table 11 (cont.)
(1981)

Group	Dates	No. of people	Areas
Nat. Outdoor Leadership School	2/19-26	20	Bull Valley, Gypsum C., Beef Basin, Ruin C., Sweet Alice C.
Enviros	3/12	34	Beef Basin
Nat. Outdoor Leadership School	3/14-15	24	Beef Basin, Butler Wash
Nat. Outdoor Leadership School	4/7-23	20	Butler Wash, Beef Basin, Gypsum C., Fable Valley, Young's C., Dark C., Lost C.
Nat. Outdoor Leadership School	4/9-16	20	Beef Basin, Gypsum C., Butler Wash, Sweet Alice C.
Wilderness Institute	5/3-16	18	Butler Wash
Outward Bound	5/7-17	43	Young's C., Dark C., Trail C., Ruin C., Ruin C., Poison C., Sweet Alice, Beef Basin, Fable Valley
Outward Bound	9/14-24	44	Beef Basin, Ruin Park, Calf. Canyon, Sweet Alice, Fable Valley, Poison Canyon, Trail C., Young's C., Dark C.
Outward Baound	10/11-22	44	Beef Basin, Ruin Park, Calf. Canyon, Sweet Alice, Fable Valley, Poison Canyon, Trail C., Young's C., Dark C.
Enviros	10/23-25	11	Beef Basin, Butler Wash
	87	278	

Table 12. Number of boat trips and passengers through Cataract Canyon (1976-1981).

Year	No. Trips	% Increase	No. Passengers	% Increase
1976	279	---	4864	---
1977	300	8	4809	-1
1978	325	8	5575	16
1979	344	6	5728	3
1980	380	10	6115	7
1981*	329	---	---	---

* 1981 figures are based on January-October.

Table 13. Responses of desert bighorn sheep to human disturbance.*

Case No.	Group composition	Group size	Distance to disturbance (m)	Response sheep
A. Boat disturbance				
1.	Rams-ewes-lambs	>7	0-75	Little to none
2.	Rams-ewes-lambs	>7	0-75	Little to none
3.	Rams-ewes-lambs	>7	0-75	Little to none
4.	Rams-ewes-lambs	>7	75-300	Little to none
5.	Rams-ewes-lambs	>7	75-300	Little to none
6.	Rams-ewes-lambs	>7	75-300	Little to none
7.	Rams-ewes-lambs	>7	75-300	Little to none
8.	Rams-ewes-lambs	>7	75-300	Little to none
B. Aircraft disturbance				
1.	Rams	2-7	75-300	Extreme
2.	Ewes-lambs	>7	300	Little to none
3.	Rams-ewes-lambs	2-7	75-300	Extreme
4.	Rams-ewes-lambs	2-7	300	Little to none
5.	Rams-ewes-lambs	2-7	300	Little to none

Table 13. Continued.

B. Continued.

6.	Rams-ewes-lambs	2-7	300	Little to none
7.	Rams-ewes-lambs	2-7	300	Little to none
8.	Rams-ewes-lambs	2-7	300	Extreme
9.	Rams-ewes-lambs	2-7	75-300	Extreme
10.	Rams-ewes-lambs	2-7	300	Little
11.	Rams-ewes-lambs	2-7	300	Little
12.	Rams-ewes-lambs	2-7	300	Little

C. Vehicle disturbance

1.	Rams	1	0-75	Extreme
2.	Rams	2-7	300	Little to none
3.	Rams	2-7	75-300	Little to none
4.	Ewes	1	300	Little to none
5.	Ewes	1	300	Little to none
6.	Ewes-lambs	>7	300	Little to none
7.	Ewes-lambs	>7	300	Little to none
8.	Ewes-lambs	>7	300	Little to none
9.	Rams-ewes-lambs	>7	300	Little to none
10.	Rams-ewes-lambs	2-7	75-300	Little to none
11.	Rams-ewes-lambs	2-7	300	Little to none

D. Hiker disturbance

1.	Rams	2-7	0-75	Extreme
2.	Rams	2-7	0-75	Extreme

Table 13. Continued

D. Continued.

3.	Rams	2-7	75-300	Extreme
4.	Rams	2-7	75-300	Extreme
5.	Ewes	1	0-75	Extreme
6.	Ewes	2-7	0-75	Extreme
7.	Ewes	1	0-75	Extreme
8.	Ewes	1	75-300	Extreme
9.	Ewes	1	300	Extreme
10.	Ewes-lambs	>7	0-75	Moderate
11.	Ewes-lambs	2-7	75-300	Moderate
12.	Rams-ewes-lambs	2-7	0-75	Moderate
13.	Rams-ewes-lambs	2-7	0-75	Moderate
14.	Rams-ewes-lambs	2-7	0-75	Moderate
15.	Rams-ewes-lambs	2-7	0-75	Moderate
16.	Rams-ewes-lambs	2-7	0-75	Extreme
17.	Rams-ewes-lambs	2-7	0-75	Moderate
18.	Rams-ewes-lambs	2-7	0-75	Moderate
19.	Rams-ewes-lambs	2-7	0-75	Moderate
20.	Rams-ewes-lambs	>7	0-75	Extreme
21.	Rams-ewes-lambs	2-7	75-300	Moderate
22.	Rams-ewes-lambs	2-7	75-300	Moderate
23.	Rams-ewes-lambs	2-7	75-300	Little to none
24.	Rams-ewes-lambs	2-7	75-300	Extreme
25.	Rams-ewes-lambs	2-7	75-300	Little to none
26.	Rams-ewes-lambs	2-7	75-300	Little to none

Table 13. Continued.

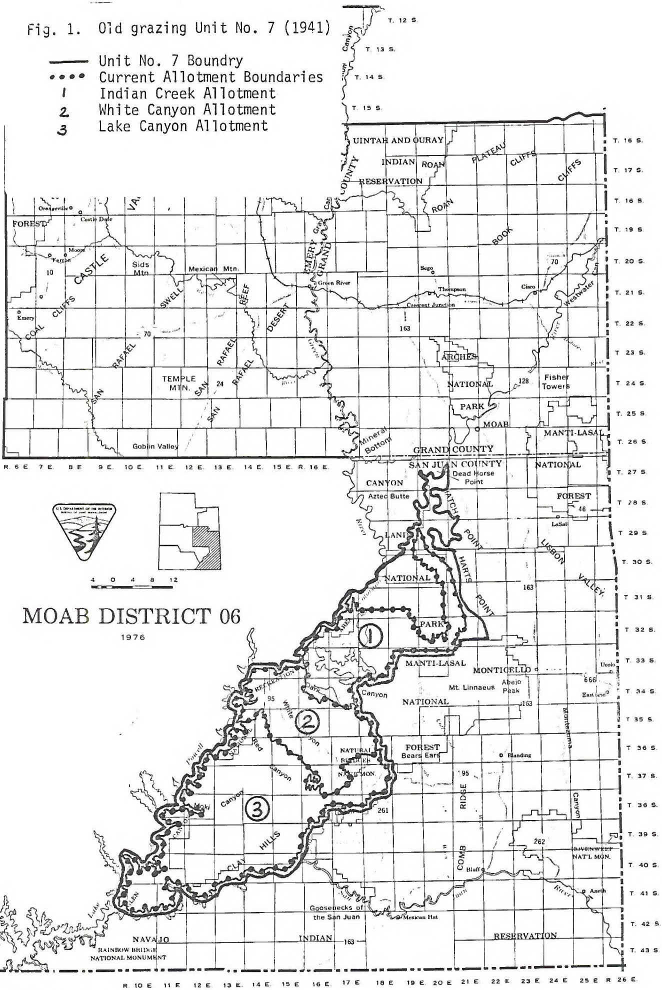
D. Continued.

27.	Rams-ewes-lambs	2-7	75-300	Moderate
28.	Rams-ewes-lambs	2-7	75-300	Moderate
29.	Rams-ewes-lambs	> 7	75-300	Moderate
30.	Rams-ewes-lambs	> 7	75-300	Moderate
31.	Rams-ewes-lambs	2-7	300	Little to none

*All interactions between sheep and recreationists were observed by the researcher.

FIGURES

Fig. 1. Old grazing Unit No. 7 (1941)



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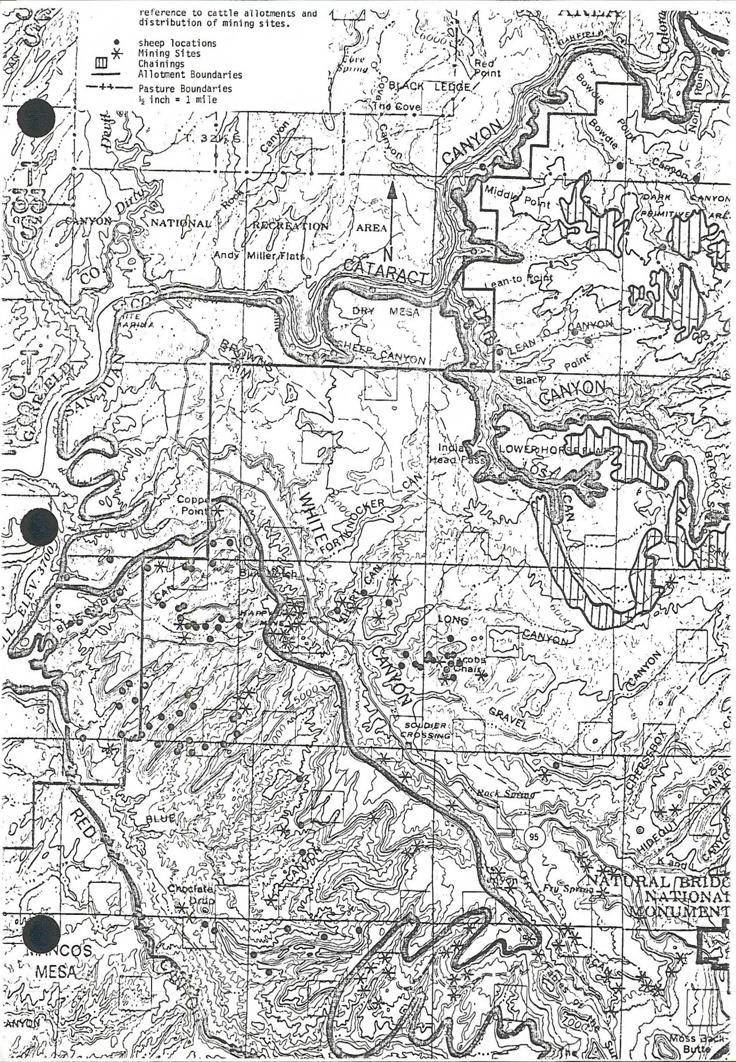

reference to cattle allotments and distribution of mining sites.
sheep locations
Mining Sites
Chainings
Allotment Boundaries
Pasture Boundaries
½ inch = 1 mile
T. 32½ S.
Red Point
BLACK LEDGE
The Cove
Cove Canyon
Rock Canyon
CANYON
Bowdie Point
Bowdie Canyon
Middle Point
DARK CANYON
PRIMITIVE AREA
GLEN CANYON NATIONAL RECREATION AREA
Dirty Devil
Andy Miller Flats
CATARACT CANYON
N
Lean-to Point
DRY MESA
SHEEP CANYON
LEAN-TO CANYON
Point
Black
CANYON
SAN JUAN
GARFIELD
BROWNS RIM
India Head Pass
LOWER HORSESHOE
LOST CAN
WHITE
FORTKNOCKER CAN.
Copper Point
ELEV. 3700
SHORT CAN
LONG CANYON
Jacobs Chair
CANYON
CANYON
GRAVEL
SOLDIER CROSSING
Rock Spring
95
CHEESEBOX
HIDEOUT
CANYON
NATURAL BRIDGES NATIONAL MONUMENT
Fry Spring
RED
BLUE
CANYON
Chocolate Drop
MANCOS MESA
CANYON
Moss Back Butte
5000
6000
7000

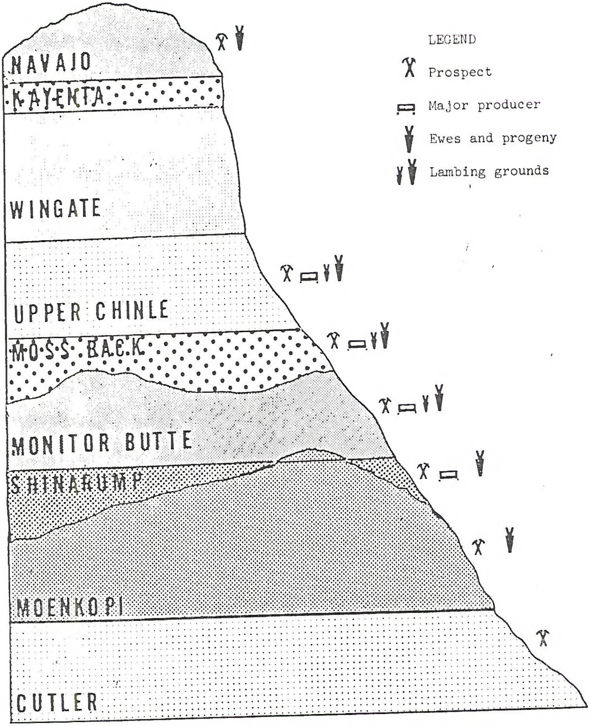
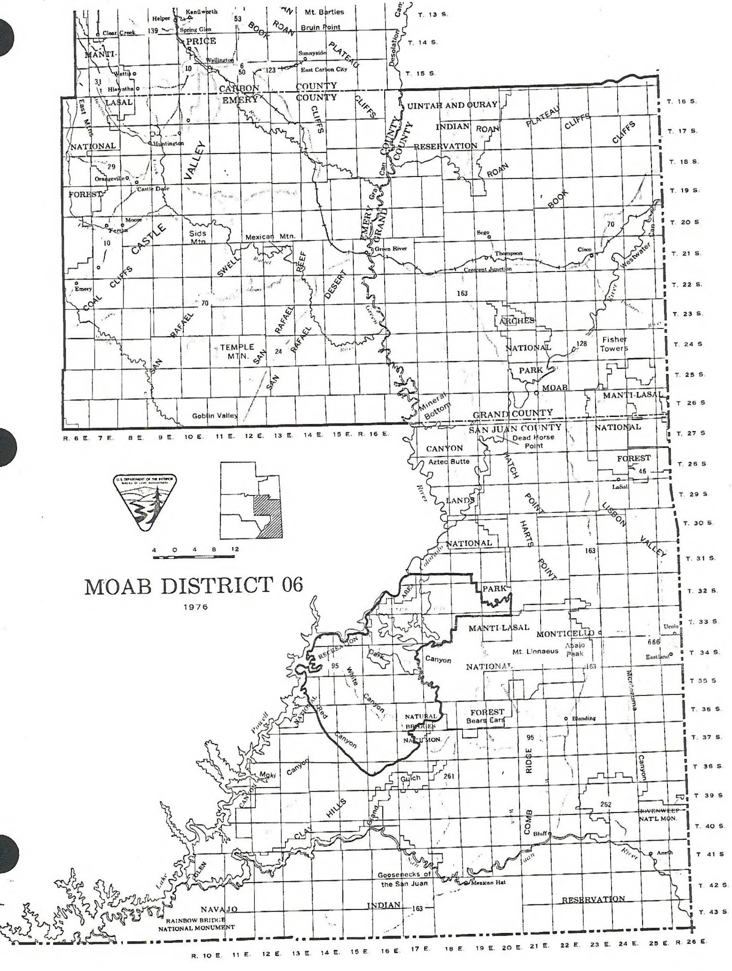


Figure 3. Location of uranium activity in relation to preferred sheep habitat in San Juan County, Utah. Modified from Irvine (1968, p. 16).

Fig. 4 BLM desert bighorn sheep study area



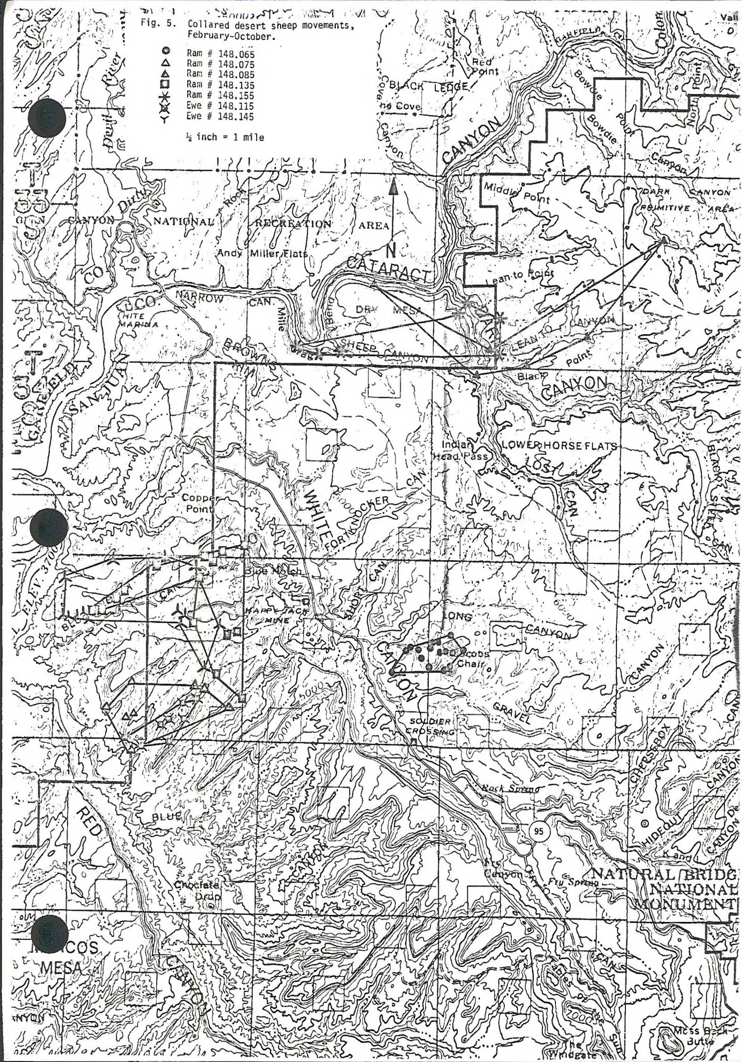
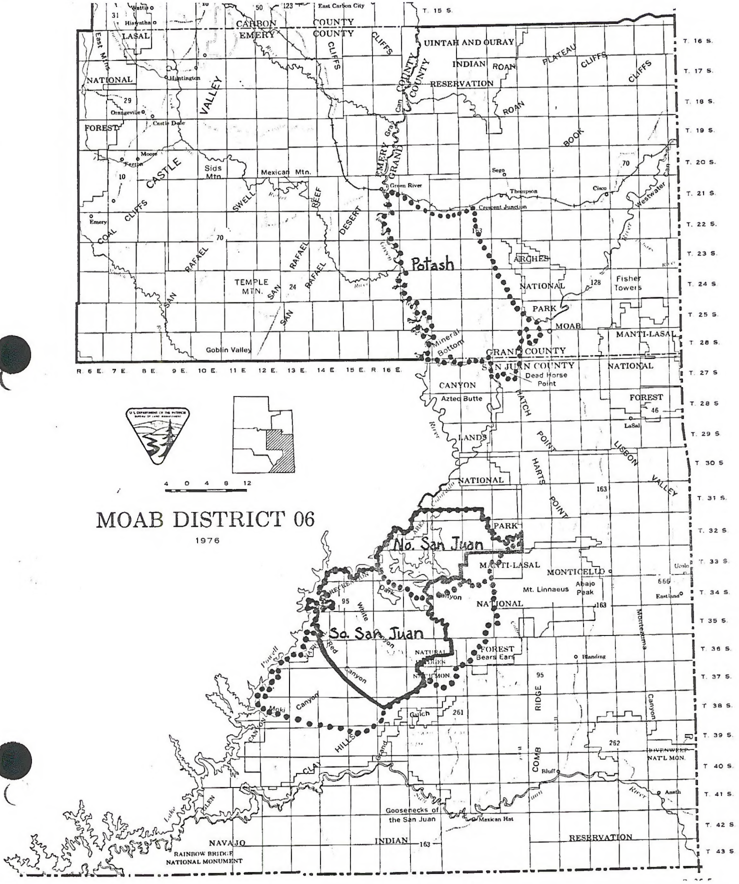


Fig. 5. Collared desert sheep movements, February-October.

Fig. 6 Desert bighorn sheep hunting units.

•••• Hunting Unit Boundaries
—— Study Area Boundry



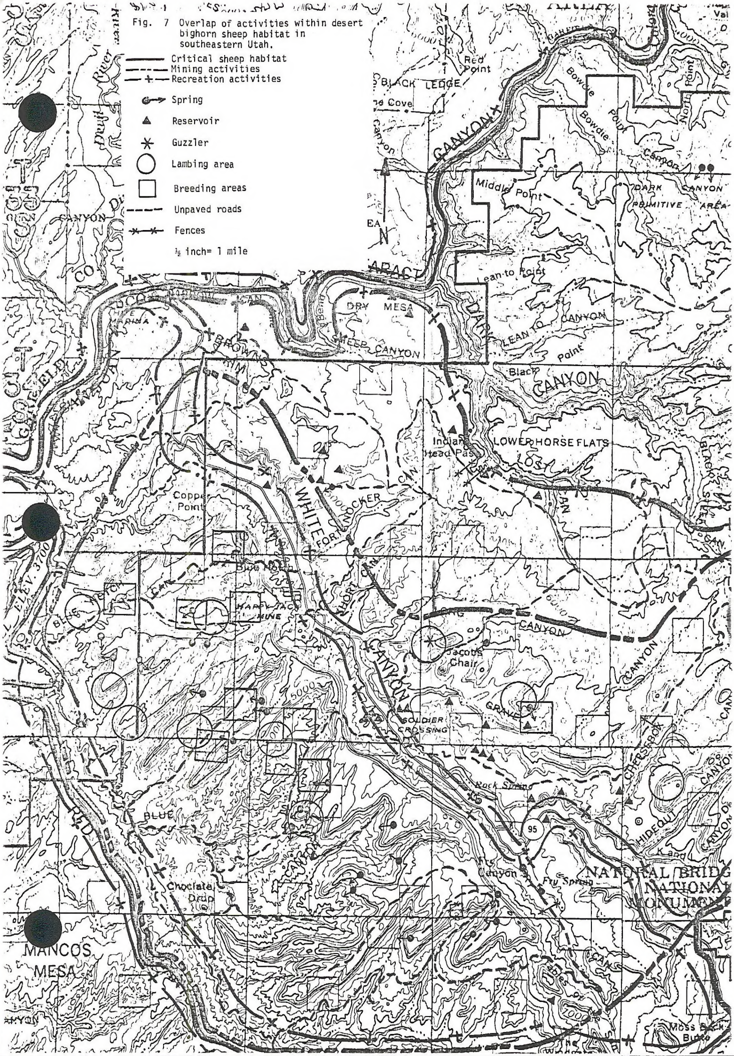
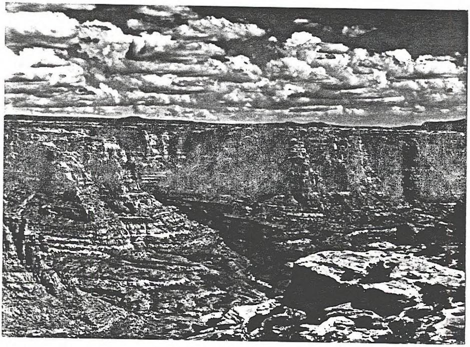


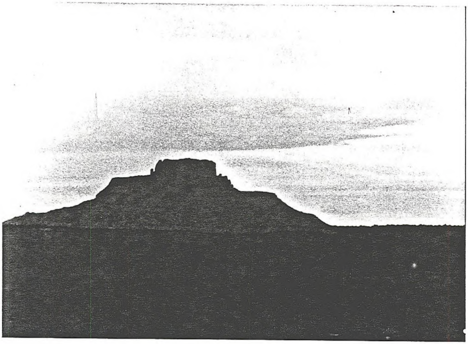
Fig. 7 Overlap of activities within desert bighorn sheep habitat in southeastern Utah.

PHOTOGRAPHS

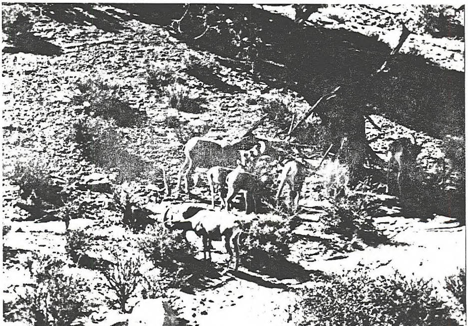
Typical desert bighorn sheep habitat in Blue Notch Canyon.



Typical desert bighorn sheep habitat in Lean-to Canyon.

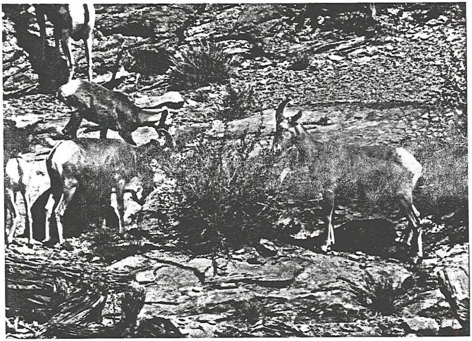


Jacobs Chair Mesa.

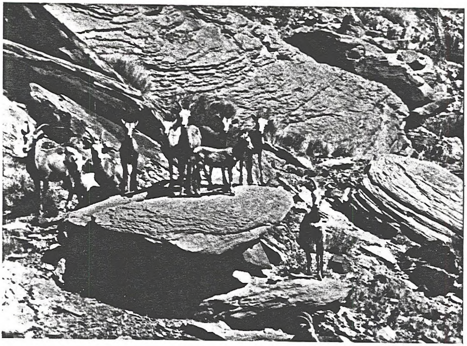


Ram # 148.065 and companions feeding on shadscale on Jacobs Chair Mesa.

Ram # 148.065 and mature ewe.

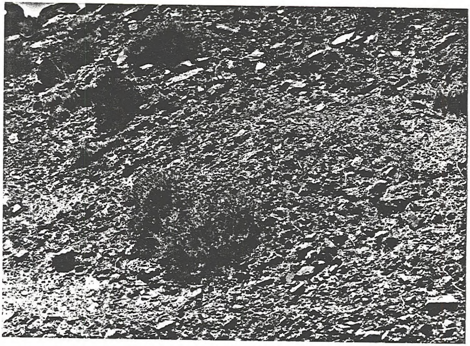


Ewes and lambs feeding on Cliffrose.

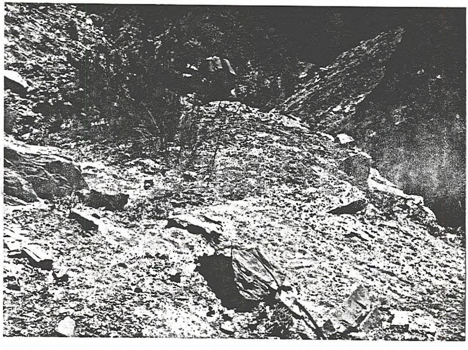


Ewe # 148.145 and companions on talus slopes in Blue Notch Canyon.

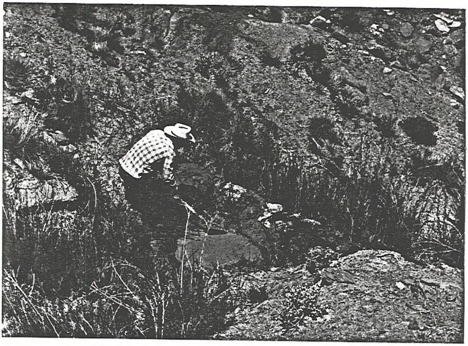
Ram # 148.135 and yearling ram on talus slopes in Blue Notch Canyon.



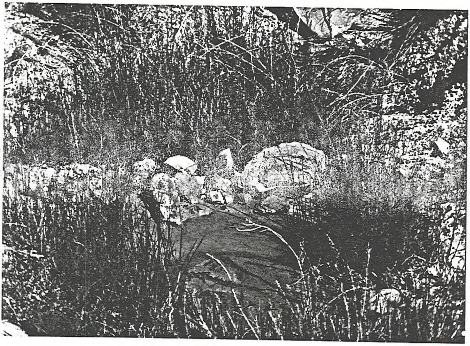
Sheep beds on talus benches in Hidden Valley.

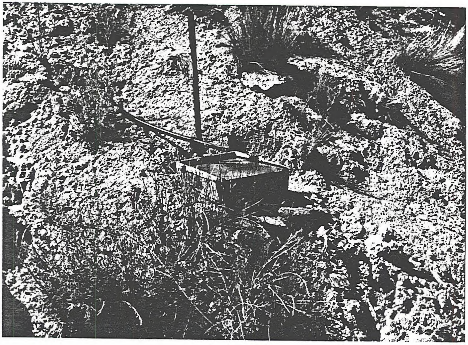


Signs of heavy sheep use at Tamarisk Spring, Hidden Valley.

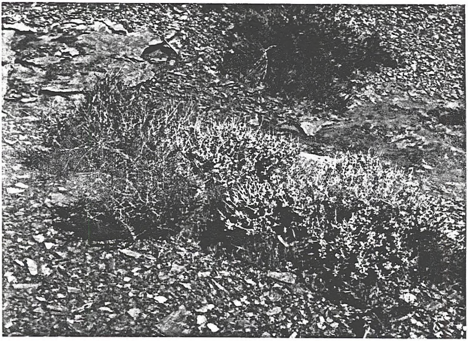


Water Development for bighorn sheep use. Rainbow Canyon.

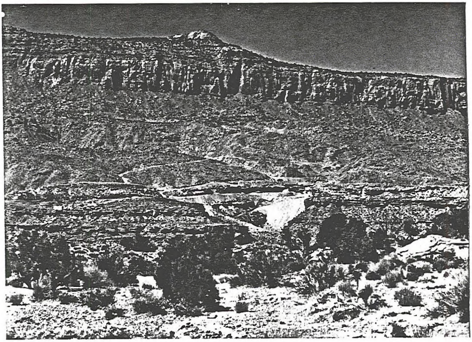




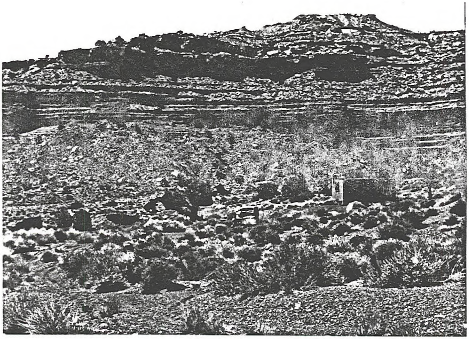
Water Development for bighorn sheep. Rainbow Canyon.



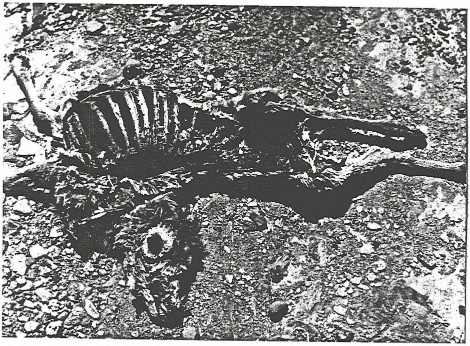
Typical summer bighorn forage, blackbrush, shadscale, ephedra.



Marquis mine, (Red Canyon) one of several, located in bighorn habitat.

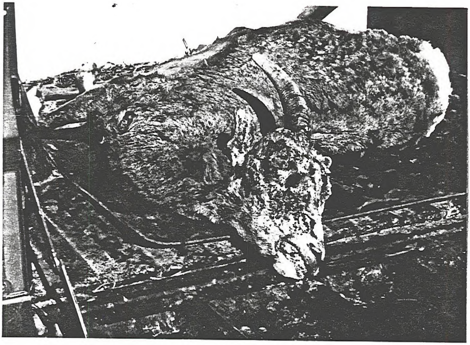


Old mine camps are common throughout the study area in bighorn habitat (Jacobs Chair Mesa)



One of 3 dead lambs found in the study area (Mahon Canyon).

Ram # 148.085 was killed by a cougar September 1981, Lean-to Canyon.



Mature ewe infected with Desert Bighorn Chronic Sinusitis,
Blue Canyon, 1979.